GRADE 12
DIPLOMA EXAMINATION

Physics 30

June 1987

Alberta
EDUCATION

PHYSICS 30 MULTIPLE-CHOICE KEY

1	A	29	C
2	B	30	B
3	A	31	A
4	D	32	D
5	C	33	C
6	D	34	B
7	A	35	C
8	D	36	A
9	D	37	D
10	A	38	D
11	C	39	B
12	A	40	D
13	C	41	D
14	B	42	B
15	B	43	D
16	C	44	C
17	B	45	C
18	C	46	A
19	C	47	A
20	D	48	C
21	B	49	B
22	D	50	B
23	C	51	C
24	D	52	A
25	B	53	A
26	C	54	B
27	A	55	C
28	C	56	B

SAMPLE ANSWERS TO THE WRITTEN-RESPONSE SECTION

Note: The responses that follow represent ONE approach to each of the problems. During the diploma examination marking session, provision is made for considering the various approaches students may have used.

Use the following information to answer question 1.

In a simplified version of Millikan's oil-drop experiment, a charged particle was observed to remain stationary in an electric field between two oppositely charged horizontal plates.
The following measurements were made:

Radius of the particle	6.05×10^{-7} m
Density of the particle	8.03×10^{2} kg/m^3
Plate separation	4.50×10^{-2} m
Potential difference across the plates	2.53×10^{2} V

(NOTE: volume = $\frac{4}{3}\pi r^3$)

(4 marks) 1. Calculate the charge on the particle. (NOTE: If you were unable to calculate a mass for the particle, use the hypothetical value of 9.20×10^{-16} kg. A solution using the hypothetical value is worth 2 marks.)

density = $\rho = m/v$

$m = \rho v$: $v = \frac{4}{3}\pi r^3$

$m = \rho(\frac{4}{3}\pi r^3)$

$= \frac{4}{3}\pi (6.05 \times 10^{-7}\ \text{m})^3\ (8.03 \times 10^{2}\ \text{kg/m}^3)$

$m = 7.45 \times 10^{-16}$ kg

$F = mg = qE$

$q = mg/E$: $E = V/d$

$q = mgd/V$

$$q = \frac{(7.45 \times 10^{-16}\ \text{kg})\ (9.81\ \text{N/kg})\ (4.50 \times 10^{-2}\ \text{m})}{(2.53 \times 10^{2}\ \text{V})}$$

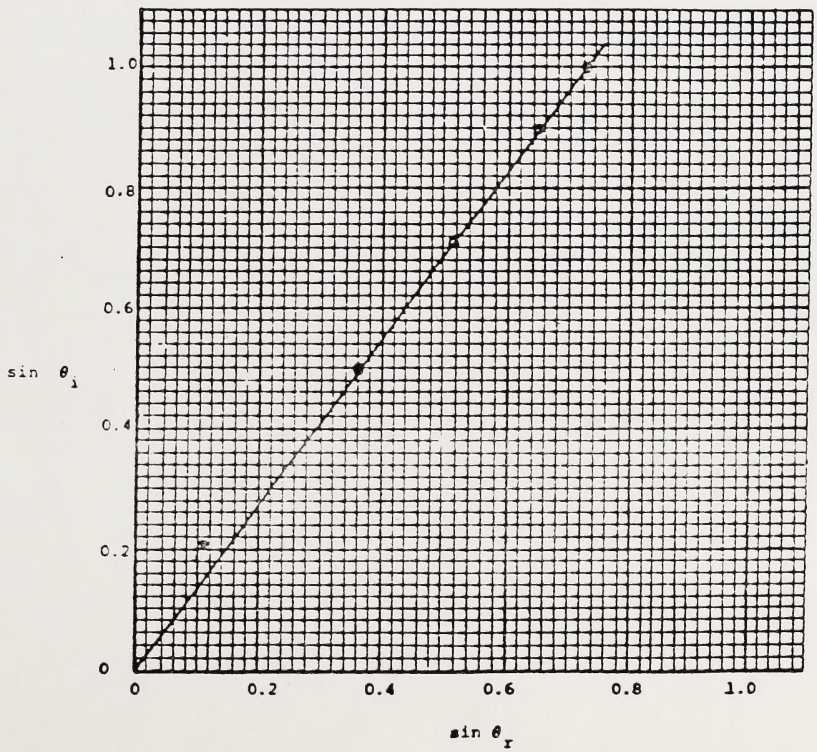
$q = 1.30 \times 10^{-18}$ C

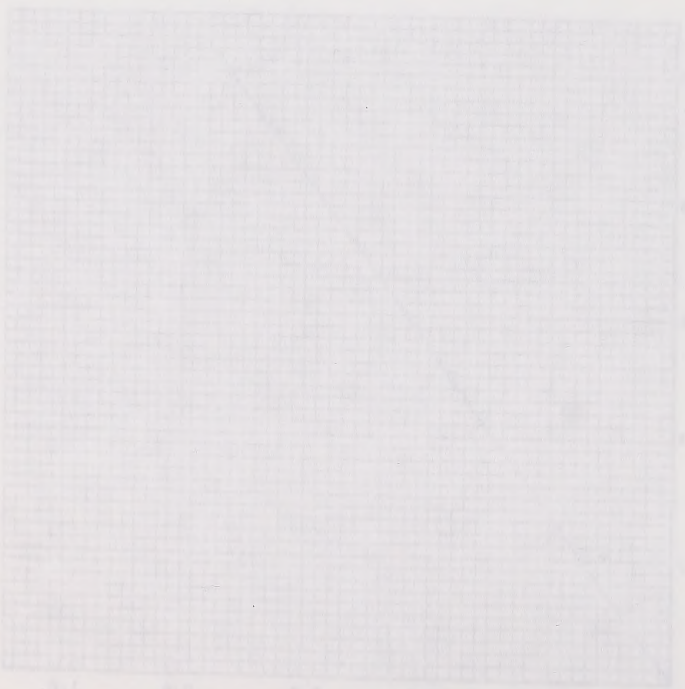
Use the following information to answer question 2.

The following data were collected in an experiment performed to determine the index of refraction of medium X. The angle of incidence (θ_i) in air and the angle of refraction (θ_r) were measured for various angles of incidence.

θ_r	sin θ_r	θ_i	sin θ_i
0°	0.000	0°	0.000
6°	0.104	12°	0.208
21°	0.358	30°	0.500
31°	0.515	45°	0.707
40°	0.643	64°	0.899
46°	0.719	90°	1.000

(2 marks) 2. a. Plot a graph of sin θ_i against sin θ_r (with the manipulated variable on the vertical axis) and draw the best-fit straight line. Be sure to label the axes.





(3 marks)

b. Using information shown on your graph, determine the best estimate for the average index of refraction of medium X. Show all your work and express your answer to two significant figures.

EITHER

$$\text{Slope} = \frac{1.0 - 0}{0.72 - 0} = 1.39$$

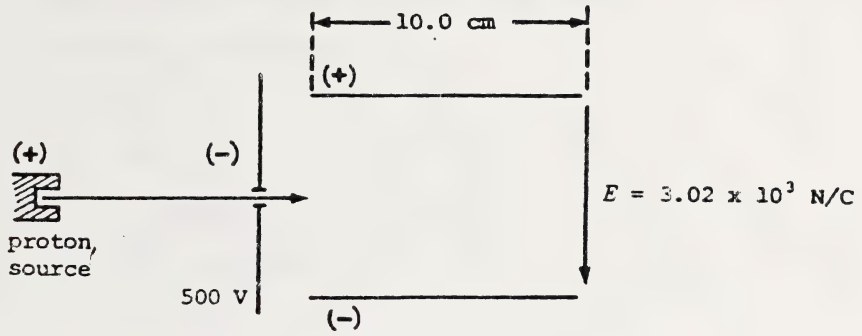
OR

Average $(\sin \theta_i)/(\sin \theta_r)$ for the last four data points.

In either case, give the answer to 2 significant figures.

Refractive index = 1.4

Use the following information to answer question 3.



Protons are accelerated across a potential difference of 5.00×10^2 V and then directed between two horizontal plates that are 10.0 cm long. The electric field between the plates is 3.02×10^3 N/C.

(2 marks) 3. a. Calculate the speed of the protons as they enter the field between the plates.

$$E_k = qV = \tfrac{1}{2}mv^2$$

$$v = \sqrt{2qV/m}$$

$$v = \sqrt{[2(1.6 \times 10^{-19}\ \text{C})(5.00 \times 10^2\ \text{V})/(1.67 \times 10^{-27}\ \text{kg})]}$$

$$v = 3.10 \times 10^5\ \text{m/s}$$

(1 mark) b. Calculate how much time it takes the protons to move through the space between the plates. (NOTE: If you were unable to calculate a value for part a. of the question, use the hypothetical value of $v = 3.61 \times 10^5$ m/s.)

$d = v_x t + \frac{1}{2} a_x t^2 : a_x = 0$

$d = v_{0x} t$

$t = d/v_{0x}$

$$= \frac{0.100 \text{ m}}{3.10 \times 10^5 \text{ m/s}}$$

$t = 3.23 \times 10^{-7}$ s

(2 marks) c. Calculate the vertical displacement of the protons upon reaching the end of the plates. (NOTE: If you were unable to calculate a value for part b. of the question, use the hypothetical value of $t = 2.77 \times 10^{-7}$ s.)

$d_y = v_{0y} t + \frac{1}{2} a_y t^2 : v_{0y} = 0$

$d_y = \frac{1}{2} a_y t^2$

$F_y = Eq = ma_y$

$a_y = Eq/m$

$$d_y = \frac{Eqt^2}{2m}$$

$$= \frac{(3.02 \times 10^3 \text{ N/C})(1.6 \times 10^{-19} \text{ C})(3.23 \times 10^{-7} \text{ s})^2}{2(1.67 \times 10^{-27} \text{ kg})}$$

$d_y = 1.51 \times 10^{-2}$ m = 1.51 cm

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **CLOSED-BOOK** examination consisting of two parts:

PART A: 56 multiple-choice questions each with a value of 1 mark.

PART B: Three written-response questions for a total of 14 marks.

A physics data booklet is provided for your reference. Approved calculators may be used.

GENERAL INSTRUCTIONS

Fill in the information on the answer sheet as directed by the examiner.

For multiple-choice questions, read each carefully and decide which of the choices BEST completes the statement or answers the question. Locate that question number on the answer sheet and fill in the space that corresponds to your choice. **USE AN HB PENCIL ONLY.**

Example

This examination is for the subject area of

A. Chemistry
B. Biology
C. Physics
D. Mathematics

Answer Sheet

A	B	C	D
①	②	●	④

If you wish to change an answer, please erase your first mark completely.

For written-response questions, read each carefully, show all your calculations, and write your answer in the space provided in the examination booklet.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET

The presiding examiner will collect the answer sheet and examination booklet for transmission to Alberta Education.

JUNE 1987

PART A

INSTRUCTIONS

There are 56 multiple-choice questions with a value of one mark each in this section of the examination. Use the separate answer sheet provided and follow the specific instructions given.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

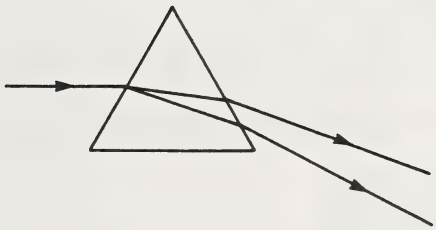
WHEN YOU HAVE COMPLETED PART A, PROCEED DIRECTLY TO PART B

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER

1. The scientists who made the first successful observations and calculations of the speed of light were

   A. Römer and Huygens
   B. Huygens and Newton
   C. Galileo and da Vinci
   D. Michelson and Morley

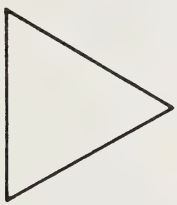
Use the following information to answer question 2.



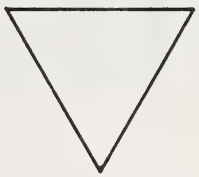
White light passes through a prism and emerges as a spectrum.
A second prism placed close to the first can re-form white light.

2. The correct orientation of the second prism is

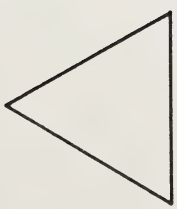
A.



B.



C.



D.

3. The blue color of the sky can be explained in terms of

   A. scattering
   B. refraction
   C. reflection
   D. polarization

4. Light behaves like a transverse wave. This is shown by experiments that demonstrate

   A. reflection
   B. refraction
   C. interference
   D. polarization

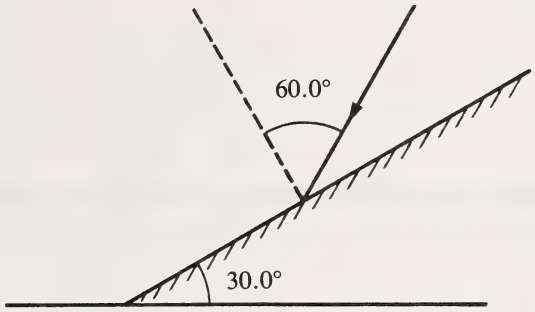
5. The ether concept was thought to be necessary to explain the

   A. refraction of light
   B. diffraction of light
   C. propagation of light
   D. polarization of light

6. Light behaves LEAST like a wave when it is

   A. polarized
   B. diffracted
   C. showing constructive interference
   D. ejecting an electron from a metal surface

Use the following information to answer question 7.

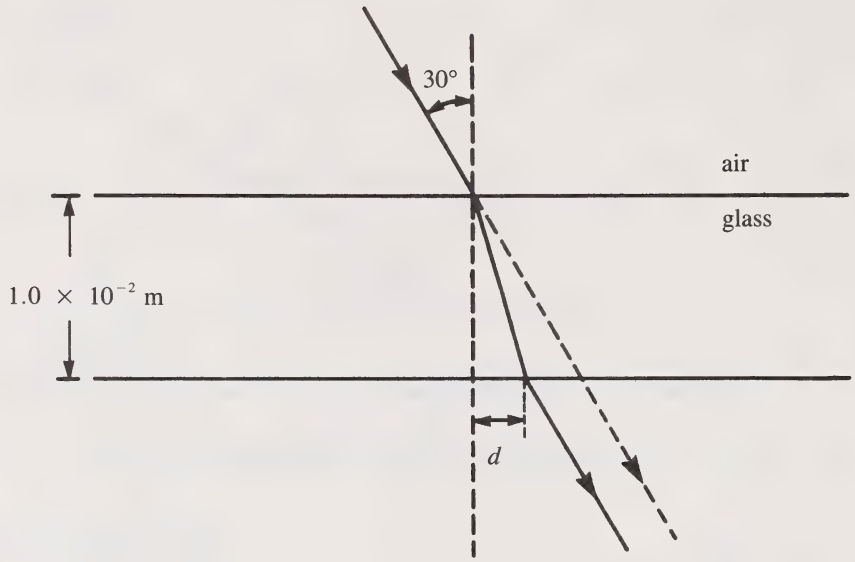


A plane mirror is positioned such that its surface makes an angle of 30° to the horizontal. A ray of light strikes the mirror at an angle of incidence of 60°.

7. The angle between the reflected ray and the horizontal is

A. 0°
B. 30°
C. 60°
D. 90°

Use the following information to answer question 8.



A glass plate that is 1.0×10^{-2} m thick has a refractive index of 1.5. A ray of light passing through air is incident on the plate at an angle of 30.0°.

8. When the ray leaves the glass, the horizontal displacement d from the normal is

A. 1.0×10^{-2} m
B. 7.5×10^{-3} m
C. 5.8×10^{-3} m
D. 3.5×10^{-3} m

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9. Given that infra-red radiation from a heat lamp has a wavelength of 8.0×10^{-7} m, which frequency represents the BEST estimate for the frequency of blue light?

A. 1.2×10^{2} Hz
B. 2.1×10^{2} Hz
C. 3.8×10^{14} Hz
D. 7.5×10^{14} Hz

10. Frequency is more reliable than wavelength for classifying colors because wavelength changes during

A. refraction
B. diffraction
C. interference
D. polarization

11. If a diffraction grating with 3.00×10^5 lines/m gives a first-order image at an angle of 10.0° on a screen that is 5.00 m away, then the wavelength of the light used is

A. 3.28×10^{-7} m
B. 5.23×10^{-7} m
C. 5.79×10^{-7} m
D. 9.98×10^{-7} m

12. If 2.4×10^{20} electrons pass a given point in a conductor every 30.0 s, the current is

A. 1.3 A
B. 77 A
C. 8.0×10^{18} A
D. 4.8×10^{20} A

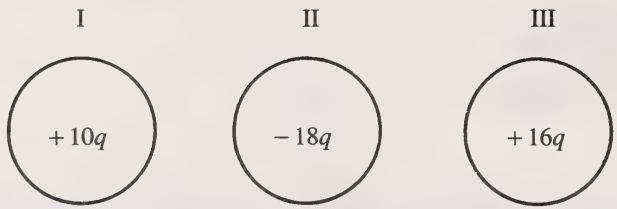
13. Which of the following can be represented by a vector field?

A. Time
B. Mass
C. Wind velocity
D. Light intensity

14. An electric field of 25.0 N/C exists between two parallel plates separated by 4.00 cm. What is the potential difference across the plates?

A. 1.60×10^{-1} V
B. 1.00 V
C. 6.25 V
D. 1.00×10^{2} V

Use the following information to answer question 15.



Diagrams I, II, and III represent metal spheres of identical size, with charges as indicated on the diagram. Sphere I is touched to Sphere II and then separated. Sphere I is then touched to Sphere III, and separated again.

15. The amount of charge on each of spheres I, II, and III respectively will be

A. $+8q,\ +8q,\ +8q$
B. $+6q,\ -4q,\ +6q$
C. $-4q,\ -4q,\ +12q$
D. $+15q,\ +15q,\ +15q$

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16. The acceleration of an electron in an electric field with a strength of 7.0 N/C is

A. 1.1×10^{-18} m/s^2
B. 9.3×10^{-12} m/s^2
C. 1.2×10^{12} m/s^2
D. 9.8×10^{12} m/s^2

17. When two small clouds, each with a charge of 2.0 C, are separated by 3.0 km, the electrical force between the clouds is

A. 2.0×10^{3} N
B. 4.0×10^{3} N
C. 2.0×10^{9} N
D. 1.2×10^{10} N

18. The units ohm, ampere, and volt respectively can be used for

A. resistance, current, and power
B. electric field, charge, and power
C. resistance, current, and potential difference
D. electric field, charge, and potential difference

Use the following information to answer question 19.

Possible ways of changing currents in a circuit:

I increase the resistance
II decrease the resistance
III increase the potential difference
IV decrease the potential difference

19. Which of the following combinations will always increase the current in a circuit?

A. I and III
B. I and IV
C. II and III
D. II and IV

---

20. If an electron accelerates from rest for a distance of 4.1×10^{-3} m through a potential difference of 2.0×10^{3} V, the kinetic energy it gains is

A. 490 J
B. 8.2 J
C. 2.1×10^{-6} J
D. 3.2×10^{-16} J

21. If a positively-charged test body is placed in an electric field where the vector E is pointing downward, the direction of the force on the test body is

A. up
B. down
C. left
D. right

22. To derive the equations $P = I^2R$ and $P = \frac{V^2}{R}$, one must use

A. Coulomb's Law and $V = IR$
B. Coulomb's Law and $P = VI$
C. Ohm's Law and $V = IR$
D. Ohm's Law and $P = VI$

23. The electromagnetic force between two very long parallel current-carrying wires is used to define the

A. volt
B. ohm
C. ampere
D. coulomb

24. In an experiment, a particle with a charge X and a velocity Z moves at right angles to a magnetic field Y. The magnetic deflecting force on the particle can be expressed as

A. $\frac{X}{YZ}$

B. $\frac{Y}{XZ}$

C. $\frac{XY}{Z}$

D. XYZ

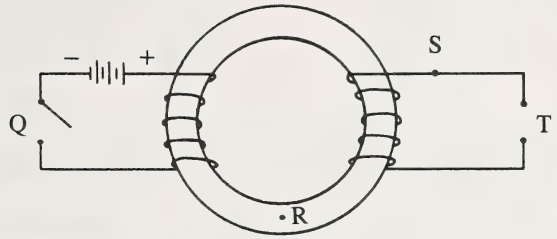
25. A singly-charged positive (1+) ion with a mass of 1.6×10^{-26} kg moves perpendicularly into a magnetic field of strength 10.0 T at a speed of 2.0×10^{5} m/s. The radius of the resulting orbit is

A. 1.6×10^{-2} m
B. 2.0×10^{-3} m
C. 1.0×10^{-3} m
D. 3.2×10^{-4} m

26. An electromagnetic wave can be generated by

A. a stationary charge
B. an accelerating neutron
C. a proton changing direction
D. an electron moving with constant velocity

Use the following information to answer question 27.



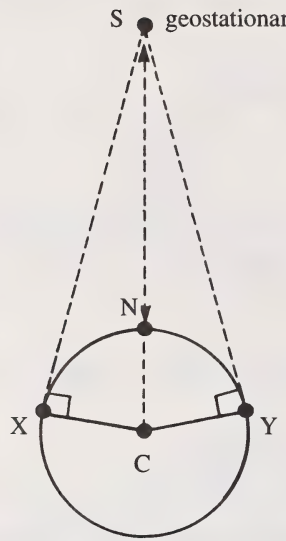
A student predicts that the closing of switch Q will

I induce a spark at point T
II induce a current at point S
III induce a voltage at point R
IV create a constant electric field at point S
V generate a changing magnetic field at point R

27. What combination of the predictions is possible as the switch is closed?

A. I, II, and V
B. I, IV, and V
C. II, III, and IV
D. II, IV, and V

Use the following information to answer question 28.



$XC = 6.4 \times 10^3$ km

$SN = 3.6 \times 10^4$ km

A geostationary satellite in an equatorial orbit is used to relay a signal from station X to station Y. C is the centre of the earth, and SNC is a straight line.

28. A signal from station X will reach station Y in

A. 0.14 s
B. 0.16 s
C. 0.28 s
D. 0.33 s

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29. The correct order, from shorter to longer wavelengths, for electromagnetic radiation is

A. ultraviolet, radio, visible
B. radio, infra-red, ultraviolet
C. X-rays, visible, microwave
D. radar, infra-red, gamma rays

30. According to Maxwell's theory, when an electron revolves around a proton, it should emit EM radiation of the same frequency as that of the electron's orbital frequency. If the time for one revolution is 2.0×10^{-15} s, the wavelength of the EM radiation emitted is

A. 5.0×10^{14} m
B. 6.0×10^{-7} m
C. 1.5×10^{-7} m
D. 6.7×10^{-24} m

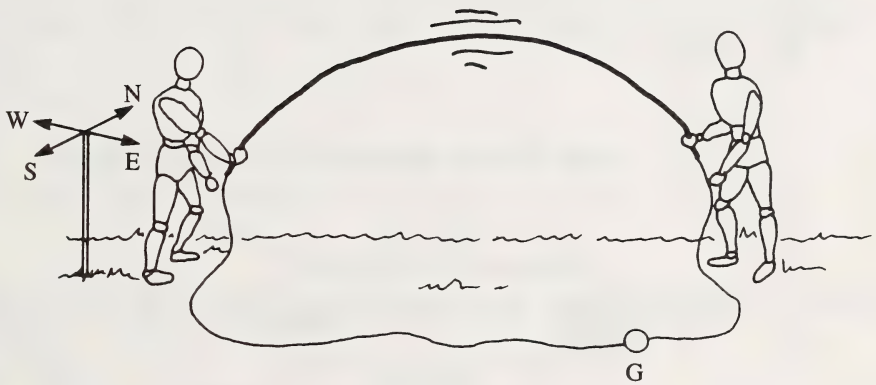
31. If a radio wave of frequency f and of wavelength λ enters a new medium and its speed changes to three-quarters of its speed in air, then its

A. wavelength will change to $3\lambda/4$
B. wavelength will change to $4\lambda/3$
C. frequency will change to $3f/4$
D. frequency will change to $4f/3$

32. In a vacuum, gamma rays and X-rays always have the same

A. source of production
B. wavelength
C. frequency
D. speed

Use the following information to answer question 33.



Two students twirl a length of wire, the ends of which are connected to a sensitive galvanometer. A third student reads the galvanometer.

33. The third student checks for deflection of the galvanometer needle and finds

A. no deflection
B. deflection to a constant maximum value
C. deflection alternately to the left and right of centre
D. deflection in one direction only, alternating between a maximum value and zero

34. Compared with visible light, X-rays have a

A. greater period
B. higher frequency
C. longer wavelength
D. lower speed in a vacuum

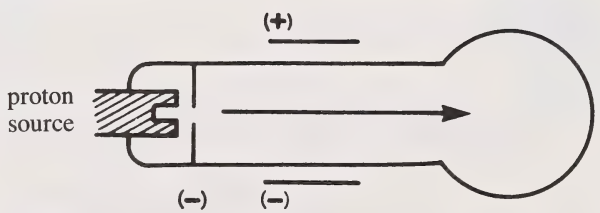
35. The Michelson-Morley experiment was important because it

A. showed motion relative to the ether
B. showed that light is diffracted by ether
C. failed to show motion relative to the ether
D. failed to show that light is diffracted by ether

36. Thomson obtained a value for the charge-to-mass ratio of cathode ray particles that was much larger than the charge-to-mass ratio of hydrogen ions. From this he concluded that the particles in cathode rays were

A. smaller in mass than hydrogen ions
B. larger in mass than hydrogen ions
C. negatively charged
D. positively charged

Use the following information to answer question 37.



A proton travels in a straight line through uniform perpendicular electric and magnetic fields. The electric field exists between two charged plates that are 2.5 cm apart and are maintained at a 275 V potential difference.

37. If the magnetic field is 2.2×10^{-3} T, the speed of the proton is

A. 1.1×10^{4} m/s
B. 5.0×10^{4} m/s
C. 1.3×10^{5} m/s
D. 5.0×10^{6} m/s

38. Elements X and Y combine to form the compound XY_2. The atomic mass of X is 14 and the atomic mass of Y is 16. What mass of element Y will react with 4.0 g of element X?

A. 2.3 g
B. 4.5 g
C. 8.0 g
D. 9.1 g

39. In an electrolysis experiment, 11 g of an element are deposited at an electrode. If the experiment is repeated with the current decreased by half and the time increased to five times the original value, then the mass of the element deposited at the electrode will be

A. 55 g
B. 28 g
C. 5.5 g
D. 4.4 g

40. A piece of platinum becomes red-hot when placed in the path of a narrow beam of cathode rays. The most direct inference from this observation is that cathode rays

A. possess mass
B. carry a charge
C. produce X-rays
D. possess kinetic energy

41. If a photoelectron is emitted with a kinetic energy of 1.6×10^{-18} J, the stopping potential of the photoelectron is

A. 0.10 V
B. 1.0 V
C. 1.6 V
D. 10 V

42. A spectroscope can be used to identify gases by

A. analysis of isotopes
B. analysis of emitted light
C. magnification of molecules
D. determination of atomic numbers

43. An electron in a hydrogen atom falls from the third to the first energy level. The frequency of the photon of light emitted is

A. 3.6×10^{14} Hz
B. 2.2×10^{15} Hz
C. 2.5×10^{15} Hz
D. 2.9×10^{15} Hz

44. Early in this century J. J. Thomson proposed an atomic model that described the atom as a sphere

A. of positive electricity about which an equal amount of negative charges orbit

B. of positively-charged and neutral particles about which negative charges orbit

C. of positive electricity in which an equal amount of negative charge is distributed

D. with a very dense positively-charged nucleus surrounded by orbiting negative charges

45. The fifth energy level of a Bohr-type atom is -2.00 eV. In an electron transition from the third to the second energy level, the energy of the emitted photon is

A. 0.28 eV
B. 1.39 eV
C. 6.94 eV
D. 8.33 eV

46. Which of the following statements summarizes Einstein's understanding of mass and energy?

A. Mass is a measure of the energy content of a body.
B. Mass is a property of particles, while energy is a property of waves.
C. Mass can be converted to energy, but energy cannot be converted to mass.
D. Mass is a property of bodies at rest, while energy is a property of bodies in motion.

47. The mass change associated with an energy change of 1.0×10^{10} J is

A. 1.1×10^{-7} kg
B. 3.0×10^{-2} kg
C. 3.3×10^{1} kg
D. 9.0×10^{6} kg

48. A particle has a relativistic mass of 7.66×10^{-27} kg when moving at a speed of $0.900c$. The rest mass of the particle is

A. 2.42×10^{-26} kg
B. 1.76×10^{-26} kg
C. 3.34×10^{-27} kg
D. 2.42×10^{-27} kg

49. If a proton has a relativistic mass of 2.1×10^{-27} kg, its speed is

A. 2.3×10^{8} m/s
B. 1.8×10^{8} m/s
C. 1.1×10^{8} m/s
D. 6.1×10^{7} m/s

50. Which statement refers to the theory proposed by de Broglie?

A. Photons have mass.
B. Particles behave like waves.
C. Waves behave like particles.
D. Energy and mass are equivalent.

51. The speed of an object that has a mass of 2.0×10^{-20} kg and an associated wavelength of 5.0×10^{-18} m is

A. 2.6×10^{-36} m/s
B. 1.5×10^{-4} m/s
C. 6.6×10^{3} m/s
D. 3.8×10^{35} m/s

52. When X-ray photons are scattered by electrons, the scattered photons

A. are of longer wavelength
B. are of shorter wavelength
C. have the same momentum as the original photons
D. have more kinetic energy than the original photons

53. The Compton effect demonstrates the

A. particle properties of photons
B. link between motion and relativistic mass
C. de Broglie wavelength of moving particles
D. existence of stable energy levels about the nucleus

54. The uncertainty principle is most significant when physicists consider the behavior of moving

A. molecules
B. electrons
C. neutrons
D. protons

55. Due to the extremely high frequency and large momentum of the photons that must be used to locate atomic particles, the motion of the located particles is greatly affected. This information was used

A. as an explanation of the Compton effect
B. as a basis for the Schrödinger wave equation
C. by Heisenberg to formulate the uncertainty principle
D. by de Broglie to calculate the wavelength of a moving stream of particles

56. According to the Bohr model, the speed of the electron in the first orbit of hydrogen is

A. 1.55×10^6 m/s
B. 2.19×10^6 m/s
C. 6.88×10^6 m/s
D. 1.38×10^7 m/s

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE SECTION OF THE EXAMINATION. PLEASE PROCEED TO THE NEXT PAGE AND ANSWER THE WRITTEN-RESPONSE QUESTIONS IN PART B.

PART B

INSTRUCTIONS

Please write your answers in the examination booklet as neatly as possible.

Marks will be awarded for pertinent explanations, calculations, formulas, and answers. Answers must be given to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

TOTAL MARKS: 14

START PART B IMMEDIATELY

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Use the following information to answer question 1.

In a simplified version of Millikan's oil-drop experiment, a charged particle was observed to remain stationary in an electric field between two oppositely-charged horizontal plates. The following measurements were made:

Radius of the particle	6.05×10^{-7} m
Density of the particle	8.03×10^{2} kg/m^3
Plate separation	4.50×10^{-2} m
Potential difference across the plates	2.53×10^{2} V

(NOTE: volume $= \frac{4}{3} \pi r^3$)

1. Calculate the charge on the particle. (NOTE: If you were unable to calculate a mass for the particle, use the hypothetical value of 9.20×10^{-16} kg. A solution using the hypothetical value is worth a maximum of 2 marks.) **(4 marks)**

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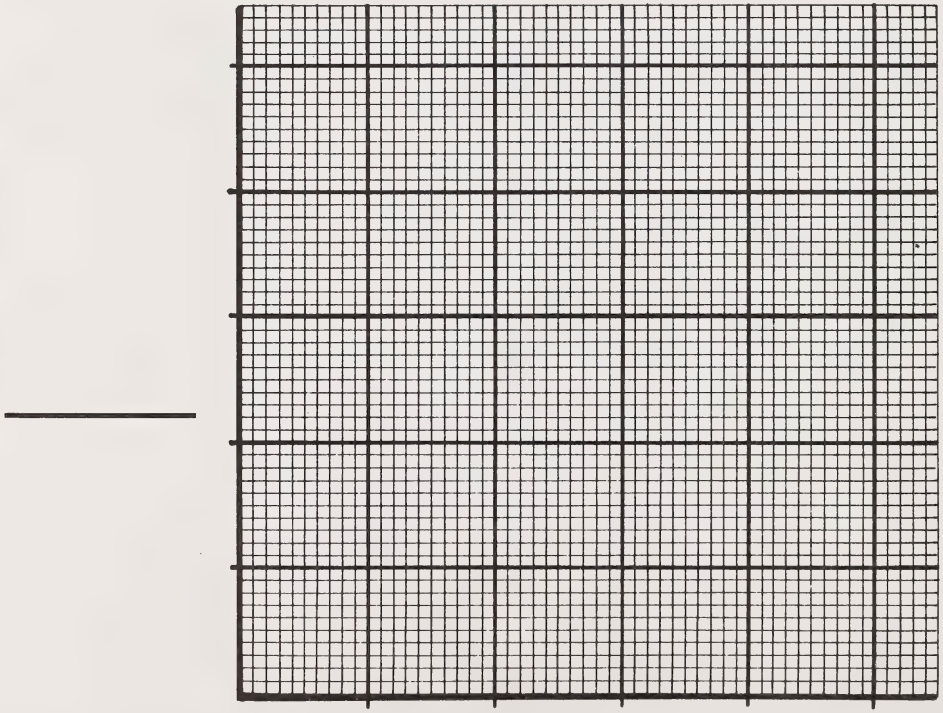
Use the following information to answer question 2.

The following data were collected in an experiment performed to determine the index of refraction of medium X. The angle of incidence (θ_i) in air and the angle of refraction (θ_r) were measured for various angles of incidence.

θ_r	sin θ_r	θ_i	sin θ_i
0°	0.000	0°	0.000
6°	0.104	12°	0.208
21°	0.358	30°	0.500
31°	0.515	45°	0.707
40°	0.643	64°	0.899
46°	0.719	90°	1.000

(3 marks)

2. a. Plot a graph of sin θ_i against sin θ_r (with the manipulated variable on the vertical axis) and draw the best-fit straight line. Be sure to label the axes.



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b. Using information shown on your graph, determine the best estimate for the average index of refraction of medium X. Show all your work and express your answer to two significant figures.

(2 marks)

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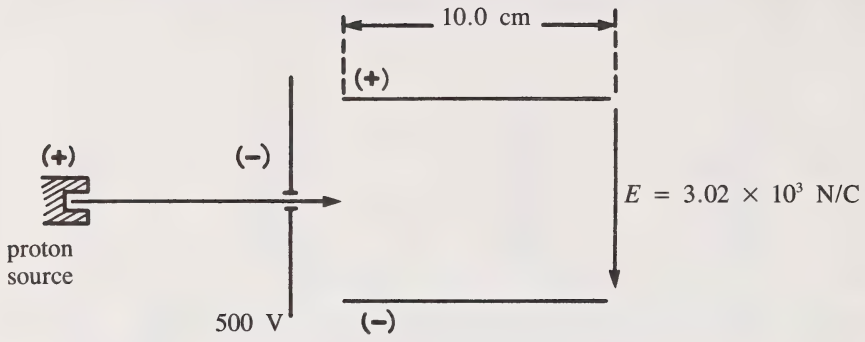
Use the following information to answer question 3.



Protons are accelerated across a potential difference of 5.00×10^2 V and then directed between two horizontal plates that are 10.0 cm long. The electric field between the plates is 3.02×10^3 N/C.

(2 marks)

3. a. Calculate the speed of the protons as they enter the field between the plates.

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b. Calculate how much time it takes the protons to move through the space between the plates. (NOTE: If you were unable to calculate a value for part a. of the question, use the hypothetical value of $v = 3.61 \times 10^5$ m/s.) **(1 mark)**

c. Calculate the vertical displacement of the protons upon reaching the end of the plates. (NOTE: If you were unable to calculate a value for part b. of the question, use the hypothetical value of $t = 2.77 \times 10^{-7}$ s.) **(2 marks)**

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

TEAR-OUT SHEET

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

FOLD AND TEAR ALONG PERFORATION

TEAR-OUT SHEET

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

FOLD AND TEAR ALONG PERFORATION

TEAR-OUT SHEET

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M1 M2 M3 M4

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PHYSICS 30

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PHYSICS 30